Teaching PDC in the Time of COVID:
Hands-On Materials for Remote Learning

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Overview

- Problem
- Goals and Strategies
- LiveDemos
- Assessment
- Observations

The Problem

- Parallel and Distributed Computing (PDC) is challenging to teach
- The COVID-19 pandemic adds to the challenge:
  - Instruction shifts from in-person to remote
  - Remote-teaching brings new challenges: how can we provide hands-on PDC learning experiences for remote (and perhaps asynchronous) students?

Three Goals

1. To provide effective *conceptual* and *hands-on* learning about multicore computing
2. To provide effective *conceptual and hands-on* learning about distributed parallel computing
3. To identify what types of PDC educational experiences are especially useful to learners

Three Strategies

For learners who may be remote/asynchronous:

1. Develop materials for multicore computing
2. Develop materials for distributed parallel computing
3. Assess what the learners find most useful.

Multicore Computing Materials

For each remote learner, send them:

1. A Raspberry Pi single board computer (R-Pi SBC), plus *instructional videos* for setting it up
   + Supports hands-on instructional goal
2. A link to a self-paced interactive module on OpenMP multithreading using the R-Pi SBC
   + The R-Pi disk image includes this module's OpenMP code
   + Supports conceptual + hands-on instructional goals
   + Written in Runestone Interactive

Demo

https://pdcbook.calvin.edu/pdcbook/RaspberryPiHandout/

Distributed Computing Materials

Three-pronged approach:

1. Develop an interactive Google Colab module on MPI basics, using mpi4py and a Google Cloud VM
2. Develop an interactive Jupyter Notebook module for MPI exemplar applications on the Chameleon Cloud
3. Develop a #2-equivalent module for running those MPI exemplars on a St. Olaf 64-core VM

All of these support both hands-on and conceptual goals and can be used either synchronously or asynchronously

Live Demo

https://colab.research.google.com/drive/1yxusXcFQ9ea1bff4_q5iToMhGeQnmSwC?usp=sharing

(Google Chrome Recommended)

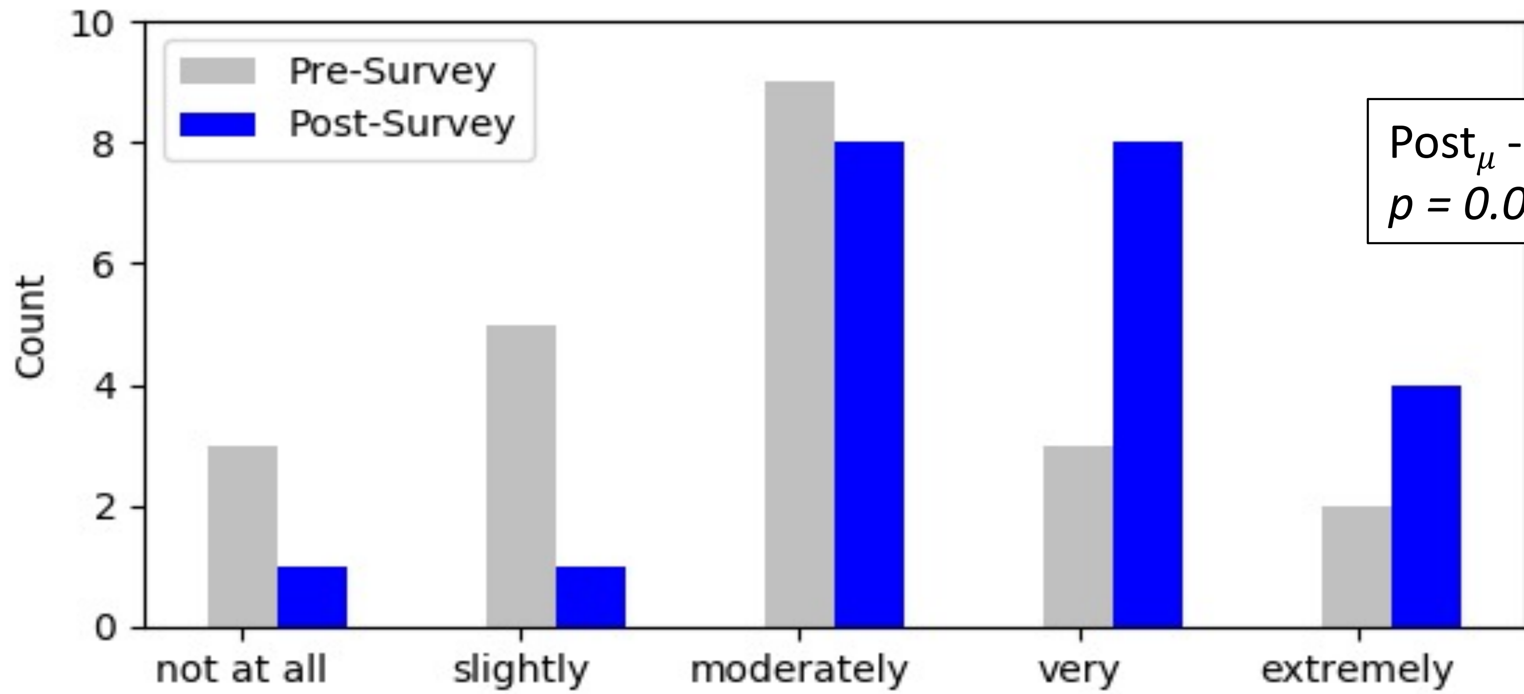
Assessment

We piloted the materials at a 2½-day CSinParallel summer 2020 virtual faculty workshop:

- 22 participants (19 U.S. 1 Puerto Rico, 2 Other)
- Basic Schedule:
  - Day 1: Shared-Memory Parallelism (OpenMP)
  - Day 2: Distributed-Memory Parallelism (MPI)
  - Day 3: Curriculum development

Pre- vs. Post-Survey Responses

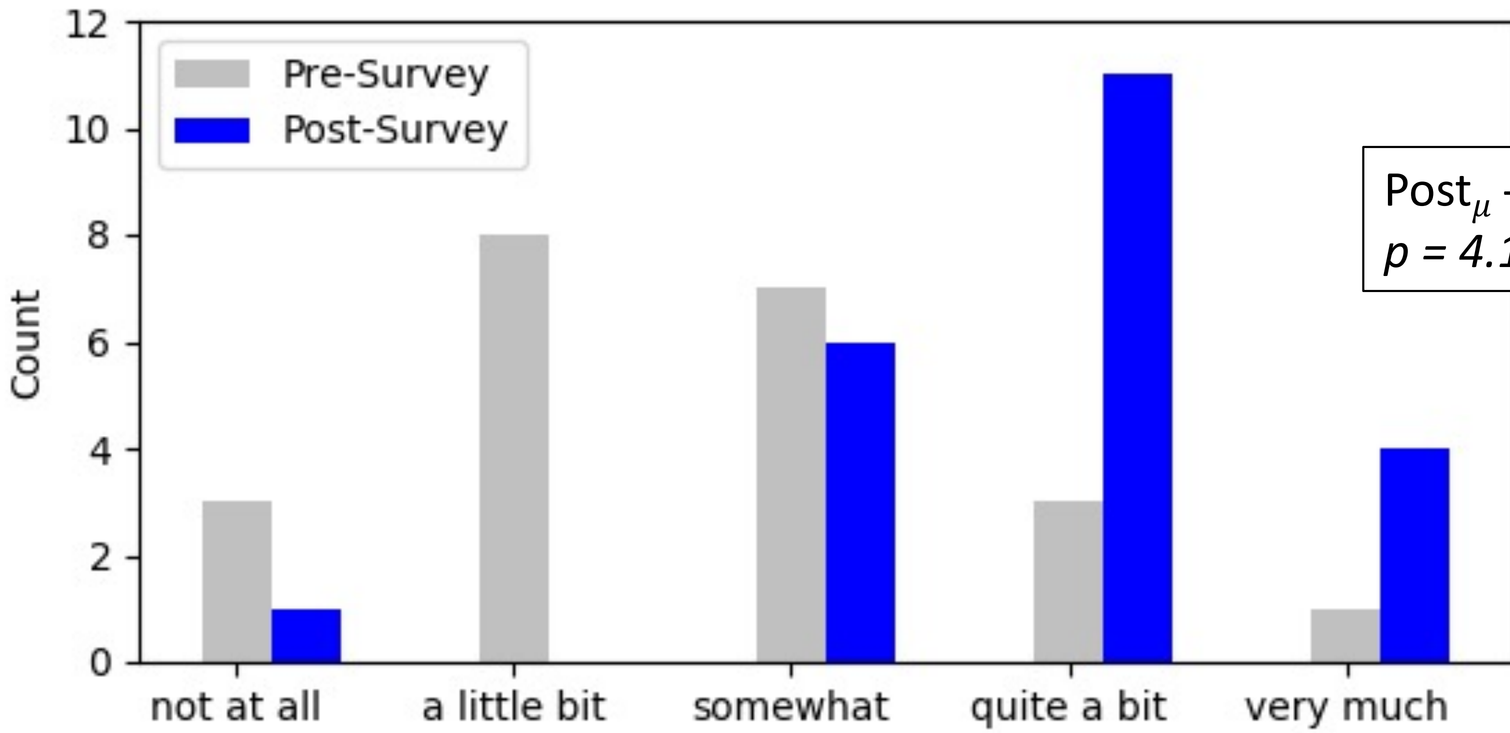
Indicate your current level of confidence in implementing PDC topics in your courses.



$Post_{\mu}$ - Pre_{μ} = +0.77
$p = 0.0004$

Pre- vs. Post-Survey Responses (ii)

How prepared to you feel to successfully implement PDC topics in your courses?



$Post_{\mu}$ - Pre_{μ} = +1.18
$p = 4.18e\text{-}8$

Likert-Scale Post-Survey Question

How useful was each session for:

(A) Implementing PDC in your courses?

(B) Your professional development?

1-Not at all useful … 5-Extremely useful

	Average Response	
Session	**(A)**	**(B)**
OpenMP on the Raspberry Pi (multicore computing materials)	**4.55**	**4.45**
MPI & Distributed Cluster Computing (distributed parallel computing materials)	**4.38**	**4.29**

Shared-Memory Observations

1. Learners found R-Pi SBCs highly motivating
   + Quad-core R-Pi is a good way to introduce OpenMP
   + Learners can *touch* the CPU, memory, etc.
   + Learners can experience *speedup* from 1 to 2,3,4 cores
2. Providing learners with R-Pi video and disk image *eliminated technical problems*
   + Standard hardware+OS greatly simplifies learner-logistics
3. R-Pi kits are *relatively inexpensive* (~$100)
   + Less than the price of some textbooks
   + Learners can use laptops as front-ends

Distributed-Memory Observations

1. Learners liked Google Colab and mpi4py
   + Good for *introducing* MPI concepts via patternlets
   - *No speedup* (the Google Colab VM is single-core)
2. They also liked Jupyter Notebook + Chameleon
   + Jupyter → simplicity; Chameleon → speedup + scalability
   - This was *difficult* to setup; Chameleon staff are essential
3. The St. Olaf 64-core VM was a good alternative
   + Participants saw *different ways to teach same topics*
   + Some learners seemed to prefer it to #2
   - "Eager beavers" caused a problem (didn't follow directions)

For More Information

- All materials are available via the workshop site:
  https://csinparallel.org/csinparallel/workshops/Virtual20/
- Contact any of us:
  - Libby Shoop: shoop@macalester.edu
  - Suzanne Matthews: suzanne.matthews@westpoint.edu
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- Thank you for attending!
- Questions?